Lawrence Livermore National Laboratory

PROGRAM UPDATE - NOVEMBER 2003

Laser Science & Technology

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Enhanced Performance of large 3ω optics using UV and IR lasers

We have developed techniques using small-beam raster scanning to laser-condition fused silica optics to enhance performance by reducing the probability of laser damage when the optics are used on NIF. Further, we showed that CO_2 lasers could be used to mitigate and stabilize damage sites while still on the order of a few tens of microns in size, thereby greatly increasing the lifetime of an optic. We recently activated the Phoenix pre-production facility (Figure 1) to condition and mitigate optics as large as 43 x 43 cm. Several full-scale optics have been processed in Phoenix.

Figure 1. Phoenix facility.

The facility is equipped with two UV conditioning lasers – a 355-nm Nd:YAG laser operating at 50 Hz with a pulse width of 3.7 ns and a 351-nm XeF excimer laser operating at 100 Hz and 23 ns. The facility also includes a CO_2 laser for damage mitigation, an optics stage for raster scanning full-scale optics, a damage mapping system that images full-scale optics and can detect damage sites or precursors as small as ~20 µm, and two microscopes to image damage sites with ~5-µm resolution. The optics are handled in a class 100 clean room within the facility that is maintained at class 1000. This facility has been used to refine the conditioning protocol used for fused silica optics and the mitigation tech-nique to reduce the downstream modulation from damage sites that are mitigated.

The optics were first photographed using a damage mapping system to identify scratches, digs, or other potential laser damage initiation sites. The damage mapping system consists of halogen side lights to illuminate the optic and a 8000 x 1 pixel linear scanning CCD camera that provides a defect detection capability of ~20 µm. Figure 2 shows a typical map of an optic prior to conditioning.

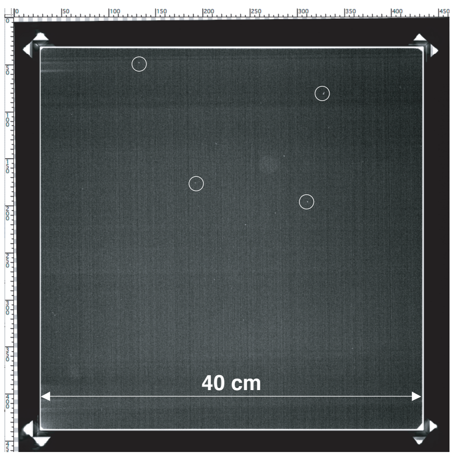

Figure 2. Image of the full-size optic showing some of the initial defects circled.

We then condition the optic, raster scanning with the excimer laser, which operates at 280 mJ/pulse and uses a one-dimensional beam homogenizer to tailor the beam profile delivered to the optic. This homogenizer converts the 24- x 12-mm beam from the laser into a 1.5- by 0.3-mm focal spot. The intensity profile at the focus is a top hat along the long axis and a Gaussian along the short axis. The spatial profile as a function of distance near the beam focus was measured. Due to the relatively small f-number of the optical system (f/13), the beam cannot be focused at both front and rear surfaces simultaneously. We thus condition the output surface first,

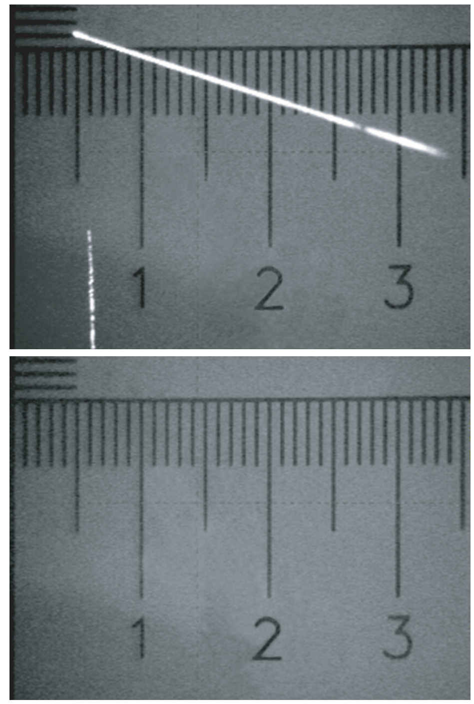

Figure 3. Example of mitigation using a CO_2 laser. The scale reads in mm.

then move the optic and condition the input surface. We start at a low fluence. A damage map is then acquired, and any new damage sites or any sites that have grown in size are mitigated using the CO_2 laser. Figure 3 shows an example of a pair of scratches that were about 100 µm wide and 1 mm and 3 mm long that were suc-cessfully mitigated with a series of 50-ms pulses from a 50-W Gaussian beam CW CO_2 laser. The process is repeated at successively higher fluences until a factor of 1.7 above the nominal operating fluence is reached. After conditioning, optics were tested in a large-beam 3ω laser and showed no damage at fluences that meet NIF operation goals.

We are currently processing and conditioning NIF optics in the Phoenix Facility.

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